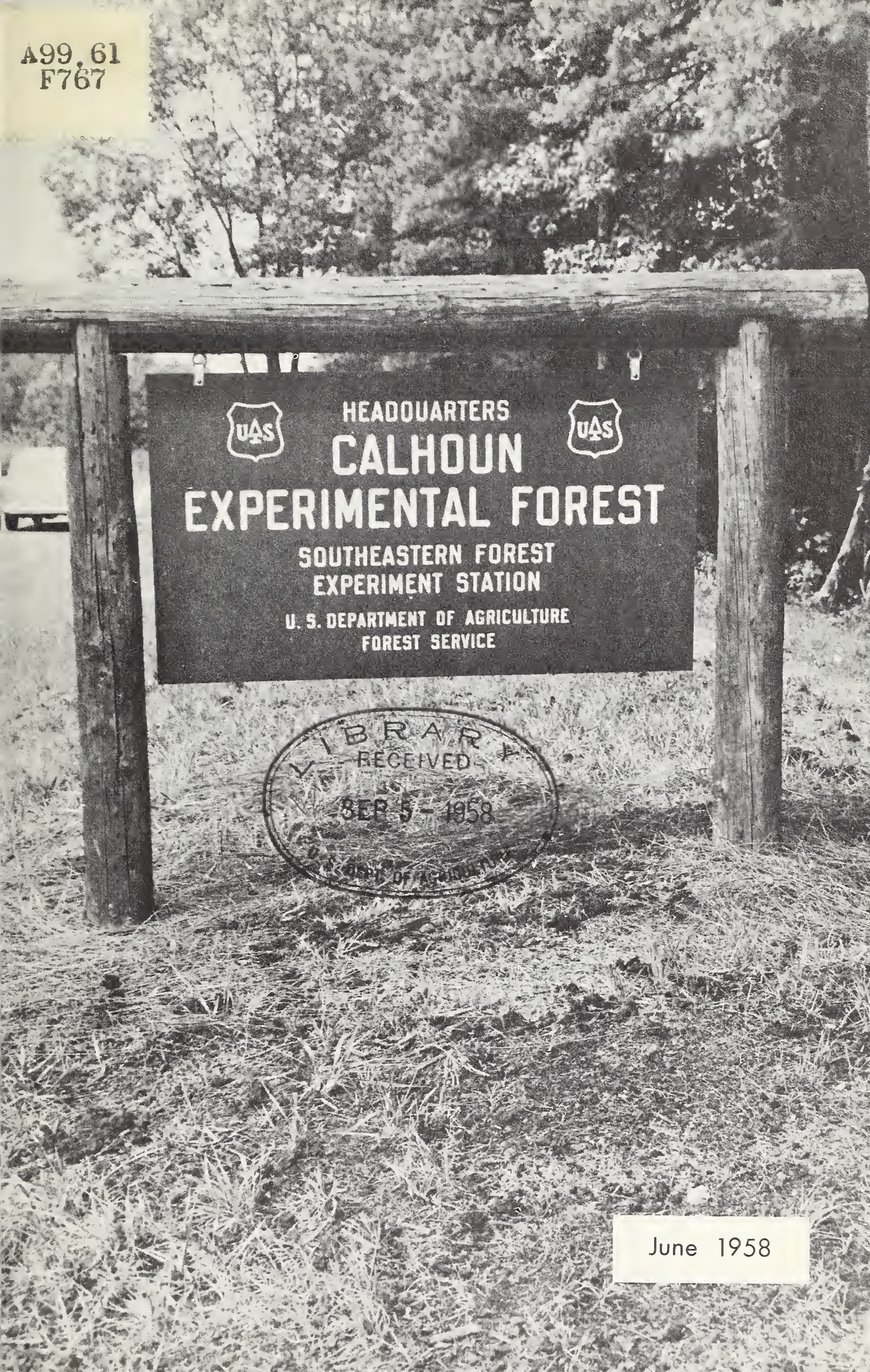
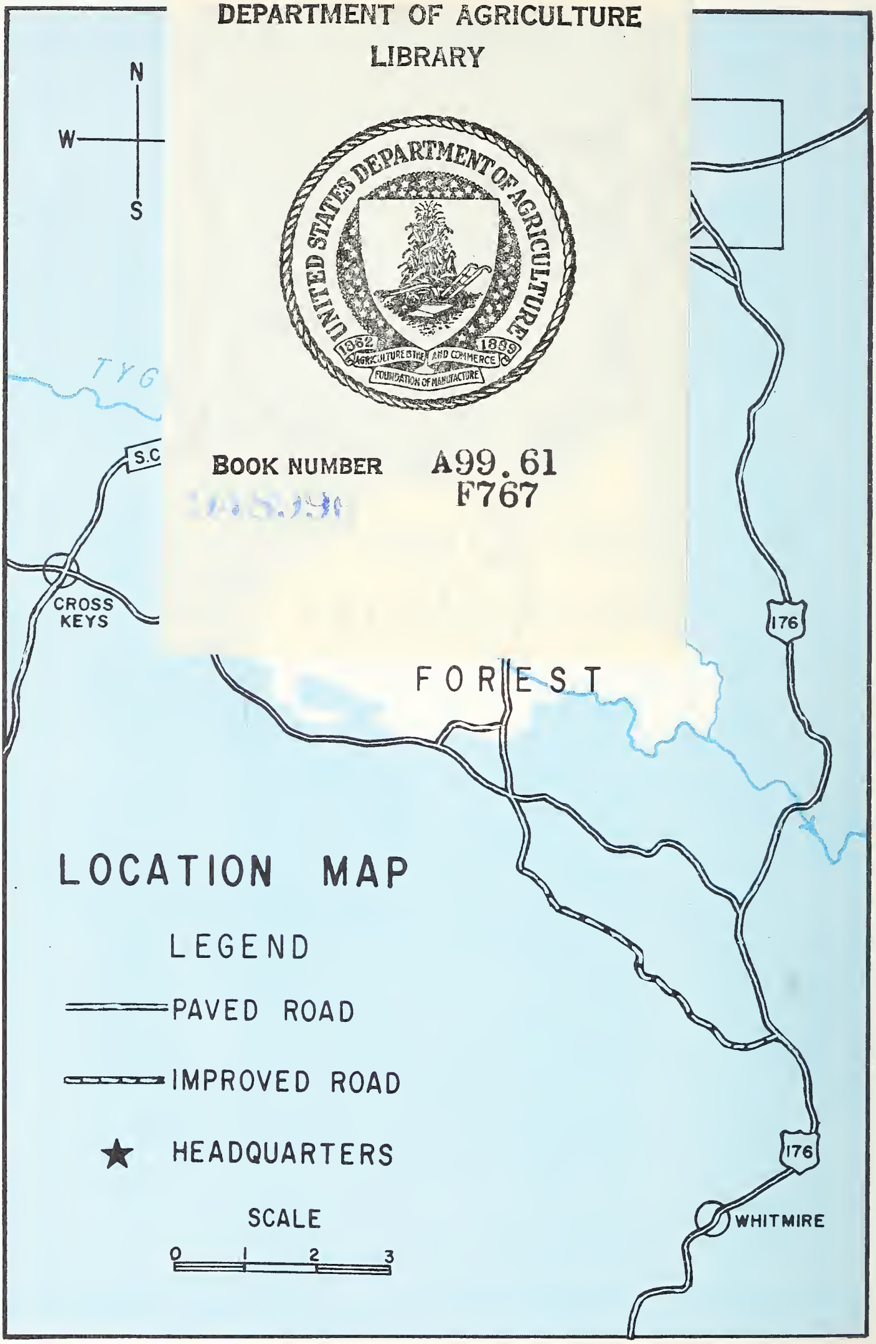

HEADQUARTERS
CALHOUN
EXPERIMENTAL FOREST
SOUTHEASTERN FOREST
EXPERIMENT STATION
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

June 1958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THE CALHOUN EXPERIMENTAL FOREST

by

Louis J. Metz

INTRODUCTION

The Calhoun Experimental Forest, a research area of the Southeastern Forest Experiment Station, was established in 1947 for work on Piedmont forest, soil, and water problems. Located in the Sumter National Forest, near Union, South Carolina, the forest was chosen because it represented poorest Piedmont conditions.

Since early settler days, the great Piedmont belt of rolling clay hills has undergone drastic changes. Not infrequently, a foot of topsoil has been lost. The subsoil is typically a tight, impervious clay that sheds water rather than taking it in and storing it. Channels of once-clear streams are now filled with eroded soil, and during rainy seasons the red creeks and rivers overflow their banks in wide swamps and floodplains.

All observers agree that this land particularly needs vegetative cover—to break the force of beating rains, prevent frost heave, shade and cool the soil, make root channels, favor soil micro-organisms, and provide organic matter on and in the soil. Trees have played a major role already in the rehabilitation of the Piedmont. They keep the soil protected year-round (in contrast to cropping) and they don't need the quantity of fertilizer that costs farmers so dear. But in many areas, tree plantations stagnate in baked clay that the roots can't penetrate, or die from lack of moisture and plant food. Such trees and soil need help.

Studies under way on the Calhoun Experimental Forest are aimed principally at soil improvement. We want to find the cheapest, quickest, most effective ways of speeding tree growth, increasing plant nutrients, and improving soil structure so that the land stores water for plant use.

WHY IS THE PIEDMONT AS IT IS?

The Piedmont region of the southeastern states has not always had a blanket of pine trees interspersed with farms, eroded abandoned land, and muddy streams. Before the white man came, the land was covered with trees, mostly hardwoods, the soils were fertile, and the streams ran clear.

Settlers along the coast began moving into the Piedmont about 1740. These earliest pioneers lived along the streams, and agriculture consisted of growing enough to feed the family and stock. More people came into the region, and since all bottomlands were settled, the slopes and uplands were used for farming. The first major crops were corn and wheat, but these were later displaced by King Cotton.

To make cropland, the forest had to be removed. If the wood was not needed, the trees were burned or girdled. After the cleared land had been cropped for a few years, the yield would so decline that new land was needed. The abandoned fields were being taken over by the light-seeded pine at the same time that more virgin forests were being removed.

These cycles of cutting, cropping, erosion, and abandonment continued and are still continuing, until some areas of the Piedmont have been in forests three or four different times.

Because such practices gobbled up land in a hurry, farmers were migrating further to the southwest in search of better lands as early as 1825. Some thought that the more farms a man could wear out the better farmer he was.

The total lack of soil-conserving practices by most farmers caused the immediate loss of the fertile topsoil. Continued poor treatment of the land resulted in erosion of the subsoil, produced gullies, and muddied the streams. Much of the fine clay and silty material moved downstream into the Coastal Plain. The heavy sand settled out quickly and began to raise the bottoms of the streams. Because this shallower channel could not carry the same amount of water it previously did, many of the once-fertile bottomlands were flooded and covered with sand.

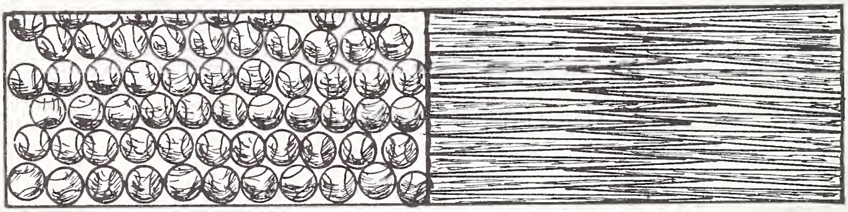


Figure 1.—Between the soil particles of good topsoil are many pore spaces, somewhat as there would be in a pile of baseballs. Studies on the Forest have shown that a square foot of such soil will take in many gallons of water per hour. Contrariwise, the structure of poor soil resembles a bundle of squeezed shingles; a square foot of some of these impervious clays will scarcely take in a pint in 10 hours. Since the water can't go in, it has to run off, producing erosion and the recurrent cycles of flood and drought.

Now after 200 years of settlement and erosion we have land with reduced productivity for trees and crops; the tough subsoil, which is now on top, produces flash runoff because it can't absorb rainfall fast enough (fig. 1); formerly productive bottomlands are frequently flooded, and muddied streams flow with either "too much" or "too little" all the time.

WHAT CAN BE DONE ABOUT IT?

Obviously, there is no magic cure-all that will restore the earth to its original condition. But many remedies can gradually improve it — and perhaps even pay for themselves as the restoration continues. These are the remedies and processes that especially concern us.

Soil is built of rocks and organic matter, acted on by weather and animal life over hundreds of years. Man's main contribution comes from building up the organic matter content of the surface soil.

Organic matter does more than darken the color. Anyone who has a garden knows how it improves the workability of the soil (fig. 2). This happens because organic matter increases the large pore spaces, thus permitting ample aeration and room for moisture, the very qualities important to the rapid entry of water and to plant growth.

When organic matter in the form of plant debris falls to the soil, it becomes food for the myriads of bacteria, fungi, and very small insects and animals. These attack or devour the material and in so doing hasten its physical and chemical breakdown. For example, a square foot of pine litter may contain as many as 1,000 mites, small animals practically invisible to the naked eye — yet all living and working and eating. Hardwood litter is more palatable than pine litter to many soil organisms. It also contributes much more nitrogen, calcium, and magnesium to the soil. For example, studies on the Experimental Forest have shown that hardwood litter deposits about 88 pounds of calcium per acre per year to the forest floor, whereas pure pine stands contribute but 20 pounds.

Thus the leaves and branches that fall to the ground are the very lifeblood of the soil. Anything that destroys the organic blanket in the forest, such as fire, grazing, and poor logging practice, is going to be harmful to some degree. Poor logging practice (fig. 3) can include such things as cutting too many trees from the forest at one time (excessive exposure permits the sun to "burn up" the organic matter before it can move into the soil), burning (this deprives the soil of organic matter), and improper location of logging roads (this can cause considerable erosion). On some areas we must encourage certain hardwoods because of the more rapid decomposition of the litter. And of course, tree planting is necessary. On old fields where a layer of topsoil remains, planting is a relatively simple job. However, on eroded areas, it may be necessary to do some preparatory work, such as mulching or planting cover crops, so that trees are not killed by poor soil conditions, excessive heat, or lack of moisture.

In essence, this all boils down to getting and keeping a layer of organic matter on the soil surface, which in turn is accomplished by getting a cover of vegetation on the land.

Figure 2.—Upper photo, loose, crumbly surface soil under an old-growth hardwood stand. This land has not been cropped in over a hundred years, and is in top hydrologic condition. You can push your hands into it almost to the wrists. Lower photo, sandy soil of an old field in loblolly pine. This wornout Piedmont land was producing cotton until trees were planted about 20 years ago. It is hard and feels almost like cement.

Figure 3.—There are more ways than one to mistreat a forest. Burning ruins a lot of timber, and improper logging wastes a lot. This scene, taken near the Experimental Forest several weeks after the loggers left, shows several practices which cost the landowner, the logger, and the consumer. The high stump in the background contains much good wood, the logs in the center are sound and large enough for sawing, and the partially cut yellow-poplar on the left is just getting to the size of rapid growth when it would have laid on much valuable wood each year. Such practices do not help the forest economy in the Piedmont, or for that matter, in any other region of the country.

CONDITIONS ON THE EXPERIMENTAL FOREST

Studies at the Calhoun Experimental Forest are concerned with soil, trees, and water. These resources are so interrelated it is often necessary to work with all three at the same time.

Most of the soils on the Forest were productive in the distant past. The predominant series of the more productive soils are Cecil and Lloyd. These deep, well-drained soils produce good stands of timber if they are not too eroded. Some soils, even with the topsoil present, are only considered fair in productivity because of the tough plastic clay near the surface. Such a soil, which is rather widespread on the Forest, is the Vance series.

When water enters the soil, some is held in the small pores and subsequently used by vegetation, and some is detained in the large pores for only a day or two and then soaks in deeper or becomes runoff. The temporary storage is very important because it helps reduce the flash runoff immediately after a rain storm. Studies on the Calhoun have shown that a productive soil which is uneroded and has not been cultivated for many years can temporarily store up to 3.0 inches of water in the surface foot, whereas many old fields hold less than 1.0 inch. This is due in great part to the organic matter in the soil; by laboratory analysis, the surface foot of soil in the old forest contains 80,000 pounds per acre of organic matter, while the same quantity of soil under a young pine stand growing on an old field contains about 25,000 pounds.

A large portion of the forest was formerly cultivated (fig. 4), but the vegetation is now mostly pine. Although both shortleaf and loblolly occur naturally, shortleaf pine is the predominant species. Most of the pine stands have either an understory and/or a mixture of hardwoods in the upper canopy. There are a few ridge and slope sites with hardwood stands, but most pure hardwood areas are in small draws or on the bottoms of the Tyger River and Fairforest Creek. Over 500 acres are in loblolly pine plantations on the Forest, mostly planted in the early 40's by the CCC and WPA.

Some studies are concerned with ways to improve the understocked and diseased forest stands. Should we try to grow something on the land other than trees? introduce new species of trees? or develop strains of vegetation resistant to the adverse effects of poor site? And of course work must be done on the proper ways to establish, utilize, and regenerate healthy forest stands.

Figure 4.—Cotton used to be the money crop in the Piedmont, and most of the Calhoun Experimental Forest was at one time or another covered with white in the early autumn. Many factors have contributed to the decrease in cotton acreages, and a great part of this land is now growing trees. As land-use changed, the cotton-picker became a woods-worker.

The Tyger River and Fairforest Creek cutting across the Forest both originate in the western part of the Piedmont. Several very small permanent streams on the Forest are kept alive by springs. But essentially, all the water flow from the Forest can be considered storm flow; that is, intermittent streams and draws have water in them immediately after rains, but soon dry up.

The climate on the Forest is mild with a relatively long growing season. The mean annual temperature for the period of 1947-1957 was 65 degrees. Winter temperatures seldom fall below 10°F., but cold fronts can move in rapidly, and sudden cold snaps occur nearly every year. During the summer, temperatures often approach 100°F.

During the decade listed above, the average annual rainfall was 42 inches. It is fairly evenly distributed throughout the seasons, but frequent droughts are experienced in the summer and autumn. The summer rains are usually of high intensity, short duration, and cover a limited area. In the late autumn, winter, and early spring, the rains are usually gentle, widespread, and of long duration. Studies now in progress were designed to find out how the forest should be thinned in order to get maximum benefit from the rain. For example, under different densities how fast is the water used when growth begins in the spring, and how rapidly is the soil reservoir recharged with water when growth ceases in the fall.

Figure 5.—A fine mixed pine-hardwood stand near the Calhoun Forest. These pines are 90 years old and about 100 feet tall. The pine-hardwood litter decomposes faster than that found under pure pine stands. The surface mineral soil has considerable organic matter present.

Figure 6.—A hardwood stand of white oak, hickory, northern red oak, and yellow-poplar. This is a good site for yellow-poplar because the trees were 90 feet high when they were 50 years old. Litter decomposes rapidly here to form a deep layer of organically enriched surface soil.

In the early days the South Carolina Piedmont was covered with productive forests. Such stands, although they still exist (figures 5 and 6), are becoming more and more difficult to locate, but they do show the productive potential of the Piedmont. Although Piedmont soils are often referred to as inherently low in fertility, experimental work has shown that under good forest conditions the soil organic matter content is just as high as that found on better sites in the mountains and Coastal Plain.

Research work on the Calhoun has shown that the amount of material falling to the ground from the trees each year weighs about 4,400 pounds per acre whether the forest is pine, hardwood, or mixed. However, there is a difference as to what happens after the leaves hit the ground. The rapidly decaying hardwood litter soon breaks apart and moves into the mineral soil and enriches it. By contrast, the slowly decaying pine needles form a dense mat which gets deeper each year at the surface of the soil.

Even though a layer of pure pine needles won't improve the soil much, it is valuable because it halts erosion and slows down the movement of water over the land.

The Littleleaf Disease

Poor land use practices not only reduce forest growth but also bring about loss of timber through mortality. Perhaps the most important factor influencing the forest economy in much of the Piedmont is the littleleaf disease of shortleaf pine. Of the 11,000 acres of timberland on the Calhoun Experimental Forest — this includes bottomlands — about 7,400 acres are affected by littleleaf (figures 7 and 8).

This disease, caused by a root fungus, brings about a slow starvation of the tree. The fungus, *Phytophthora cinnamomi,* is found in soils throughout the world and causes extensive damage to such dissimilar plants as avacados, pineapples, and pine trees. In a well-drained "healthy soil" there is ample material for the fungus to feed on, but there are also many antagnostic organisms which tend to keep it in check. However, in the tight, poorly-drained clays of the Piedmont, this water-loving fungus runs rampant. Working on the fine roots, it kills them and thus they can no longer take up the nutrients the tree needs. As the roots absorb less and less nitrogen, calcium, and other elements, and since new root formation

Figure 7.—A healthy stand of shortleaf pine in the upper South Carolina Piedmont.

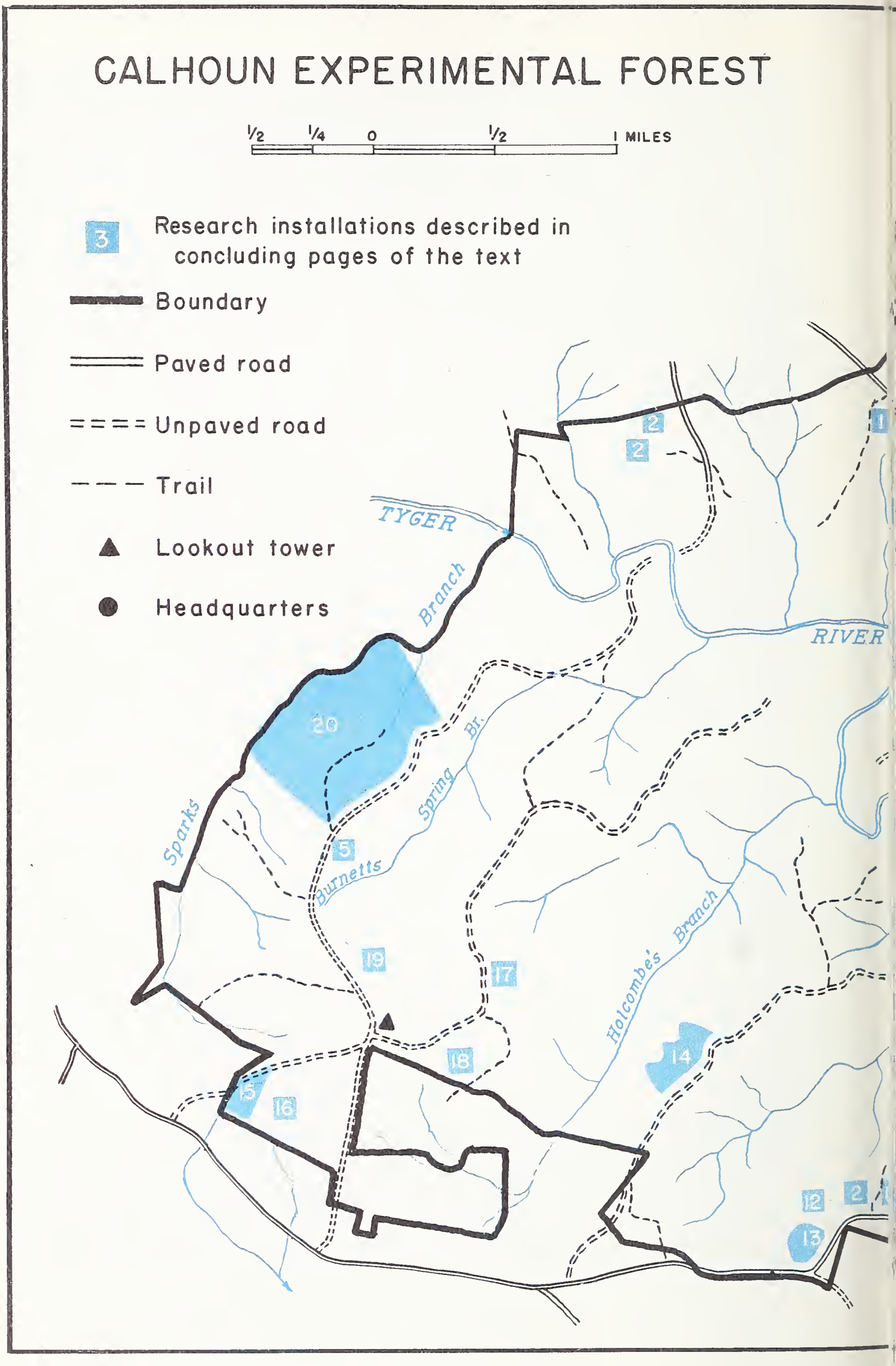
Figure 8.—A stand of shortleaf pine in the South Carolina Piedmont about 50 years old, badly broken up by the littleleaf disease.

is slow in these poorly aerated soils, the tree weakens and dies. This killing process may take from 2 to 10 years, depending on the severity of the root damage.

If a tree in your backyard gets littleleaf you can usually restore it with heavy applications of nitrogen fertilizer. However, in the forest such a treatment would usually cost too much money. The final solution to the littleleaf problem will come when we restore soil fertility — that is, so improve the physical and chemical characteristics that the fungus can be held in check and roots can grow fast enough to overcome fungus damage.

In the meantime, what can we do? Cutting methods have been worked out by the pathologists and foresters so that much diseased timber can be salvaged before the trees die. Examples of these cutting practices can be seen on the Forest.

Where littleleaf occurs, loblolly pine is usually preferred for planting over shortleaf pine in the upper Piedmont. But this will not guarantee a stand, because it has been found that loblolly pines are also susceptible to the disease, although to a lesser degree than shortleaf. Studies are under way to develop a strain of shortleaf pine resistant to littleleaf, and some examples of field work on this project can be seen on the Calhoun.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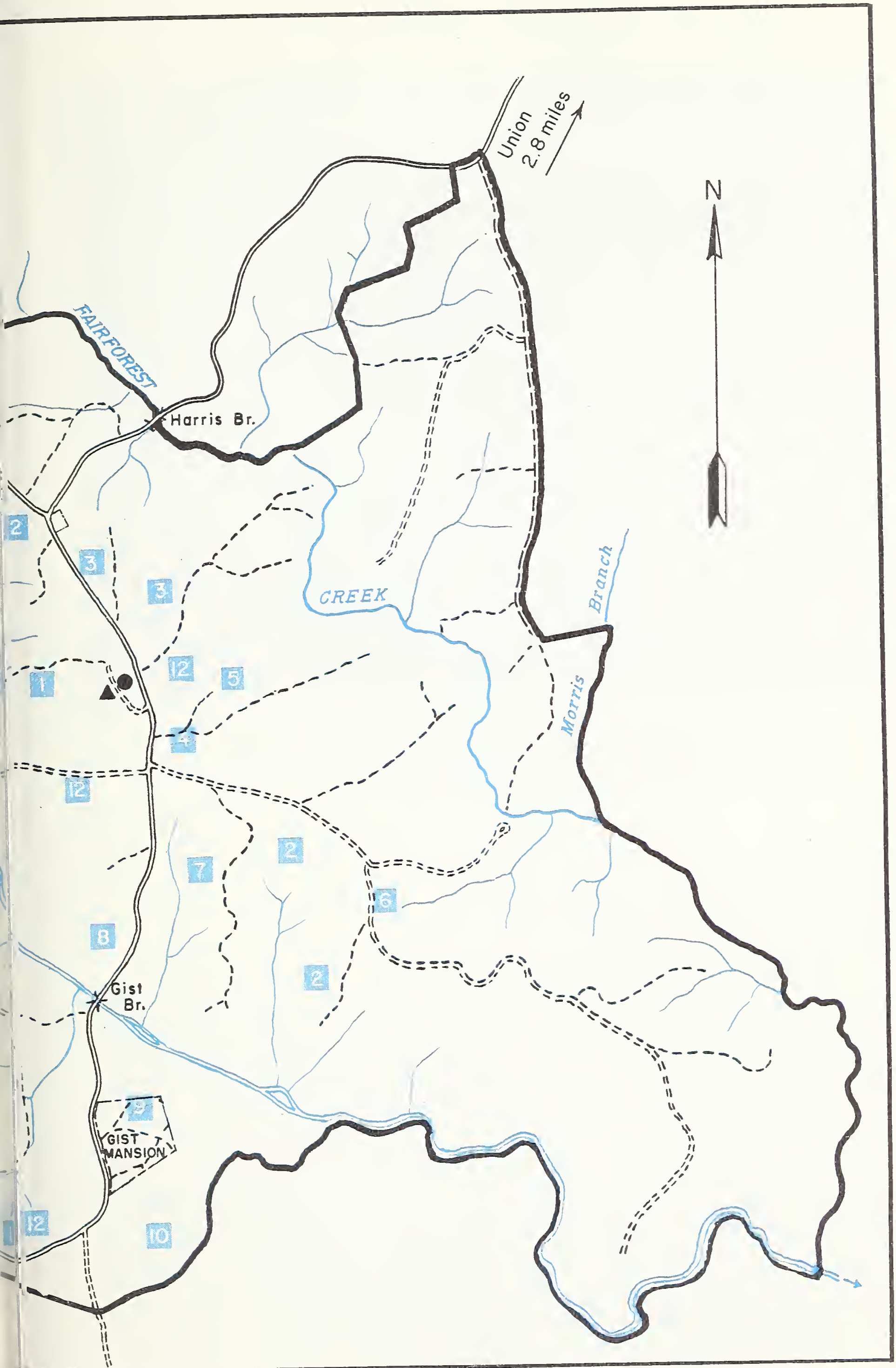
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Figure 9.—Abandoned as a cotton field, this eroding and barren area was planted to trees, but the trees died.

Improving Eroded Areas

The 13-acre watershed shown in figure 9 was planted to trees in 1941, the year after it had been abandoned as a cotton field. In the upper, flatter portions there was still some sandy surface soil left and the trees survived. In the exposed red clay, however, the trees grew for a few years and died. Erosion continued. Next a weir was installed on this small watershed, which then had 9 acres of planted trees and 4 acres of exposed subsoil. Flow of water was measured for 5 years while the area was in this condition. Then, in accordance with standard practices used by many landowners in the Piedmont, the exposed soil was smoothed, seeded, fertilized, and mulched. In a few months the sericea and crotalaria formed a good cover, as shown in figure 10 (taken in August 1954). The serecia has become progressively denser each year. This simple treatment has been very effective; it has drastically reduced peak flow of water, greatly delayed time of initial runoff after rain, and stopped soil loss. Because water now soaks into the soil, the area has a chance to improve instead of deteriorating.

Figure 10.—Revegetated with sericea and crotalaria, the old field is becoming more fertile each year.

If left to nature, the red clay shown in figure 9 will not ordinarily become covered with vegetation. Exceedingly high summer temperatures and an 18-inch layer of desiccated soil prevent most seed from germinating, and the few that do, soon wither and die.

On bare areas such as this, the heavy clay soil at first resists erosion and is eaten away at a slow rate. Most loss is due to the intense summer thunderstorms and frost heaving in the winter. Frost heaving, which occurs up to a dozen times each winter, raises a thin veneer of soil. When the ice crystals melt, the soil rests on the surface as a loose fluffy layer and even the drizzly rains of winter will move it from the site. However, once the red clay is broken through, the soil melts away like sugar, and gullies deepen many feet each year. The material underlying the clay is a mixture of finely decomposed rock with few clay particles to bind it together.

What can happen to an area — the ultimate in land abuse — is shown in figure 11. This land can only be reclaimed at great expense.

When land is abused, the surface soil will not absorb water. Silt-laden water of years past has raised the level of the stream bottoms in the Piedmont. The wide flood plains of rivers and streams are covered many times each year with water as shown in figure 12.

Figure 11.—This large gully started many years ago as a slightly eroded cut in an abandoned cotton field. Left unchecked, it grew until thousands of tons of soil had been moved to the streams below. The effort now needed to repair the damage proves that an ounce of prevention is worth a pound of cure.

Figure 12.—Bridges in the Piedmont have to span the flood plain as well as the river.

If soil cannot absorb water, it cannot store it. As a result, during periods between rains the amount of water fed to streams is very small. Figure 13 shows the same stream during low flow. The photo was taken from the bridge shown in figure 12. The sandbar was at one time topsoil on land upstream. The material continues to move downstream until caught behind a reservoir. This lost soil decreases the value of the land from which it came, lowers value of bottomlands it covers, and in many indirect ways, such as increasing the cost of city drinking water, is costly to everyone.

Figure 13.—The crossing shown in figure 12 shrinks to a small, shallow channel.

THINGS TO SEE ON THE CALHOUN EXPERIMENTAL FOREST

The map on pages 12 and 13 shows the location of many of the research installations on the Forest. The areas on the map are identified by numbers which correspond with those given below:

(1) A test planting of various hardwoods was made on some poor sites. Survival and growth have been poor. Although the litter from hardwoods will improve the site, the oaks and yellow-poplar will hardly manage to survive on the poorest sites.

(2) Plots were established in shortleaf pine stands affected with littleleaf on six different soil series. These plots have been valuable in showing the influence of soil material on the incidence of littleleaf and the length of time it takes the trees, once infected, to die.

(3) A soil moisture study was established in a young loblolly pine plantation to study the effect of thinning on soil-moisture depletion and recharge.

(4) A study was established — before the cause of littleleaf was known — to see whether the disease is caused by something moving from one part of a tree to another. Tops from diseased shortleaf pine were grafted to roots from healthy young trees. When these grafts were planted in good soil, the tops soon recovered and the trees are still growing in a healthy condition.

(5) A study on loblolly pine was set up in cooperation with the Tennessee Valley Authority to test seedlings from different seed sources. Seed came from 10 different locations between Mississippi and Maryland, and trees were planted in 1950. Identical plantings were made at seven other locations in the South.

(6) A number of littleleaf-resistant shortleaf pine have been selected for study. The healthy trees, growing on a poor soil in the midst of diseased trees, furnish seed and shoots for propagation.

(7) Virginia pine has been suggested as an alternative species on poor Piedmont soils. This interplanting was made on an area in which a littleleaf salvage cut had been made.

(8) This hill shows littleleaf disease in all stages and was the first place where the disease was noted in South Carolina.

(9) This small area of private land contains the closest thing we have to a virgin soil on the forest. There has been no farming on this area in over 100 years and the forest has been an oak-hickory mixture. Gradual removal of oak has left an almost pure hickory overstory.

(10) This shortleaf pine planting, established in 1952, is part of a study made in cooperation with the Southern Forest Tree Improvement Committee. Over 50 locations throughout the South are being used to study the probable origin and present distribution of longleaf, slash, loblolly, and shortleaf pines.

(11) Shortleaf pine from 12 different geographic areas ranging from Georgia to Oklahoma to New Jersey were planted here. These plots were established to see whether trees from different locations may have a resistance to the littleleaf disease.

(12) These plots were used to check the soil-moisture relations under different cover types. Moisture is determined in the surface 6 feet of soil on these plots by means of electrical resistance units buried at various depths. The resistance is recorded by a meter, and the ohms are then converted to inches of water. Much field and laboratory work is needed for studies such as these (figures 14 and 15).

Figure 14.—Collecting samples in an old field just beginning to seed in naturally to pine. From the samples it is possible to determine the percolation rate, pore-size distribution, and bulk density of the soil. The man in the pit is operating a soil-sampling apparatus.

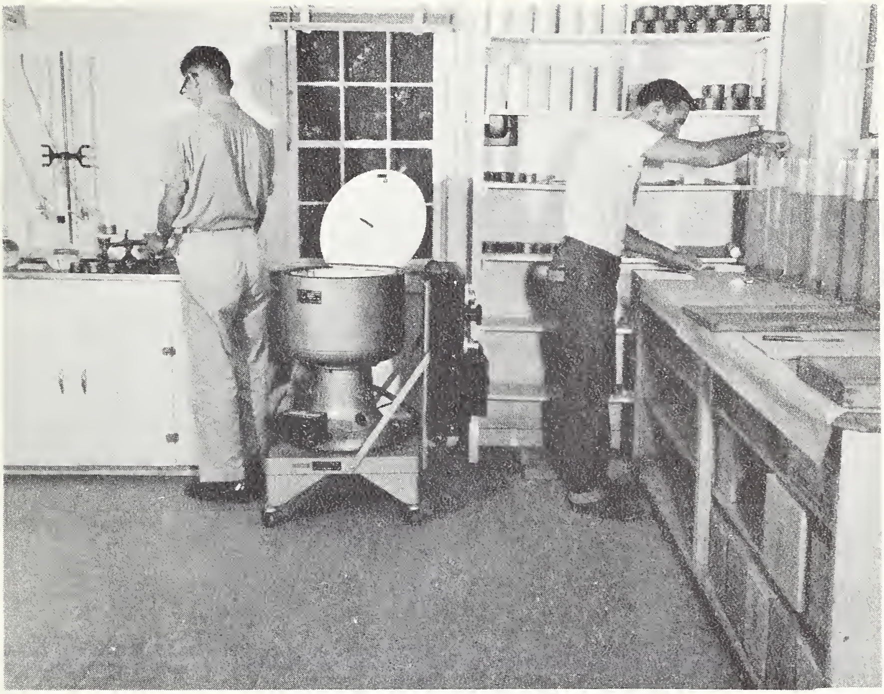

Figure 15.—In the laboratory a man on the left is weighing the soil sample while the man on the right determines texture (percent of sand, silt, and clay). The centrifuge that stands between them is used for studying soil moisture.

(13) This is the 13-acre watershed shown in figures 9 and 10. Soil moisture studies have taken place here and a weir measures the water flowing from the area.

(14) These plots are for a long-term study of soil rehabilitation. All three areas showed moderate littleleaf damage when the experiment started. One area is being left in pine, one is being converted to a pure hardwood stand, and the third is being converted to a pine-hardwood mixture.

(15) This is a study in which loblolly pine was planted 6x6, 8x8, etc. This planting, to be used in the future for litter and soil-moisture studies, has been repeated in North Carolina.

(16) This is a planting of stock raised from seed of ordinary shortleaf pine and from seed and vegetative stock of trees mentioned in (6) above.

(17) Here is one of many examples of severe erosion in the Piedmont.

(18) A planting of Virginia pine was installed in cooperation with the Division of Forest Insect Research to test the effect of various treatments on pales weevil. Trees were planted several weeks after the area had been clear cut.

(19) A comparison is here demonstrated of survival and growth of loblolly, shortleaf, Virginia, white, and slash pines.

(20) This is a several-hundred-acre demonstration tract to show the methods of cutting littleleaf stands in order to salvage as many diseased trees as possible before they die.

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Agriculture--Asheville

THE SOIL SPEAKS TO MAN

In all the world I am your provider—
I hold the sinewy roots of tall trees—
I clutch the grass and hold it aloft, waving.
The small animals are not strangers to me.
Nor the rivers,
Nor the oceans,
Nor the onslaught of rain as it runs through my hair.

I have been servant to you—tall, strong men;
You have pushed me aside, molded me, but never changed
my elements.
I have, like many Atlases, held your world on my shoulders,
Buildings, bridges, brawling bulwarks standing against
your brother-men.
And I have done naught but yield to your wishes,
brutish, mauling, scarring my skin.

I am the moist, dark earth—
Stronghold of life—
Guardian angel to you and to your sons.
I am strong, though I yield;
I am rich, and you would possess my riches.
You, the transient wanderers, will cease roaming
only to find rest once again in my grasp.
You, whom I have nourished, will nourish me,
and life will be everlasting.

DAVID F. OLSON, JR.

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